Human Spaceflight Technology Needs Mapped to OCT TABS

TABS #	OCT Technology Area	HAT Technology Need
1.	**Launch Propulsion Systems**	
1.0	*Launch Propulsion Systems*	
1.0.0	Launch Propulsion Systems	2.4.a Unsettled Cryo Propellant Transfer
1.1	*Solid Rocket Propulsion Systems*	
1.1.0	Solid Rocket Propulsion Systems	
1.1.1	Propellants	
1.1.2	Case Materials	
1.1.3	Nozzle Systems	
1.1.4	Hybrid Rocket Propulsion Systems	
1.1.5	Fundamental Solid Propulsion Technologies	
1.2	*Liquid Rocket Propulsion Systems*	
1.2.0	Liquid Rocket Propulsion Systems	
1.2.1	LH2/LOX Based	1.2.a Oxygen-Rich Staged Combustion (ORSC) Engine Technology
1.2.2	RP/LOX Based	1.2.b Advanced, Low Cost Engine Technology for HLLV
1.2.3	CH4/LOX Based	
1.2.4	Detonation Wave Engines (Closed Cycle)	
1.2.5	Propellants	
1.2.6	Fundamental Liquid Propulsion Technologies	
1.3	*Air Breathing Propulsion Systems*	
1.3.0	Air Breathing Propulsion Systems	
1.3.1	Turbine Based Combined Cycle (TBCC)	
1.3.2	Rocket Based Combined Cycle (RBCC)	
1.3.3	Detonation Wave Engines (Open Cycle)	

TABS #	OCT Technology Area	HAT Technology Need
1.3.4	Turbine Based Jet Engines (flyback boosters)	
1.3.5	Ramjet/Scramjet Engines (accelerators)	
1.3.6	Deeply-cooled Air Cycles	
1.3.7	Air Collection & Enrichment System	
1.3.8	Fundamental Air Breathing Propulsion Technologies	
1.4	*Ancillary Propulsion Systems*	
1.4.0	Ancillary Propulsion Systems	
1.4.1	Auxiliary Control Systems	
1.4.2	Main Propulsion Systems (Excluding Engines)	
1.4.3	Launch Abort Systems	
1.4.4	Thrust Vector Control Systems	
1.4.5	Health Management and Sensors	4.5.a Autonomous Vehicle Systems Management
1.4.6	Pyro and Separation Systems	
1.4.7	Fundamental Ancillary Propulsion Technologies	
1.5	*Unconventional/Other Propulsion Systems*	
1.5.0	Unconventional/Other Propulsion Systems	
1.5.1	Ground Launch Assist	
1.5.2	Air Launch/Drop Systems	
1.5.3	Space Tether Assist	
1.5.4	Beamed Energy / Energy Addition	
1.5.5	Nuclear	
1.5.6	High Energy Density Materials/Propellants	
2.	**In-Space Propulsion Technologies**	
2.0	*In-Space Propulsion Technologies*	

TABS #	OCT Technology Area	HAT Technology Need
2.0.0	In-Space Propulsion Technologies	
2.1	*Chemical Propulsion*	
2.1.0	Chemical Propulsion	
2.1.1	Liquid Storable	2.1.c Non-Toxic Reaction Control Engines
2.1.2	Liquid Cryogenic	2.1.a LOX/Liquid Methane Cryogenic Propulsion System 2.1.b LOX/Liquid Methane Reaction Control Engines
2.1.3	Gels	
2.1.4	Solid	
2.1.5	Hybrid	
2.1.6	Cold Gas/Warm Gas	
2.1.7	Micropropulsion	
2.2	*Non-Chemical Propulsion*	
2.2.0	Non-Chemical Propulsion	
2.2.1	Electric Propulsion	2.2.a Electric Propulsion & Power Processing
2.2.2	Solar Sail Propulsion	
2.2.3	Thermal Propulsion	2.2.b Nuclear Thermal Propulsion (NTP) Engine
2.2.4	Tether Propulsion	
2.3	*Advanced (TRL <3) Propulsion Technologies*	
2.3.0	Advanced (TRL <3) Propulsion Technologies	
2.3.1	Beamed Energy Propulsion	
2.3.2	Electric Sail Propulsion	
2.3.3	Fusion Propulsion	
2.3.4	High Energy Density Materials	
2.3.5	Antimatter Propulsion	
2.3.6	Advanced Fission	

TABS #	OCT Technology Area	HAT Technology Need
2.3.7	Breakthrough Propulsion	
2.4	*Supporting Technologies*	
2.4.0	Supporting Technologies	
2.4.2	Propellant Storage & Transfer	2.4.a Unsettled Cryo Propellant Transfer 2.4.b In Space Cryogenic Liquid Acquisition
3.	**Space Power and Energy Storage**	
3.0	*Space Power and Energy Storage*	
3.0.0	Space Power and Energy Storage	
3.1	*Power Generation*	
3.1.0	Power Generation	
3.1.1	Energy Harvesting	
3.1.2	Chemical (Fuel Cells, Heat Engines)	3.2.a Regenerative Fuel Cells
3.1.3	Solar (PV & Thermal)	3.1.b High Strength/Stiffness Deployable 10-100 kW Class Solar Arrays 3.1.c Autonomously Deployable 300 kW In-Space Arrays
3.1.4	Radioisotope	
3.1.5	Fission	3.1.a 300 kWe Fission Power for Electric Propulsion 3.1.d Fission Power for Surface Missions 3.1.e Multi-MWe Nuclear Power for Electric Propulsion
3.1.6	Fusion	
3.2	*Energy Storage*	
3.2.0	Energy Storage	
3.2.1	Batteries	3.2.b High Specific Energy Batteries 3.2.c Long Life Batteries
3.2.2	Flywheels	
3.2.3	Regenerative Fuel Cells	3.2.a Regenerative Fuel Cells

TABS #	OCT Technology Area	HAT Technology Need
3.3	*Power Management and Distribution*	
3.3.0	Power Management and Distribution	
3.3.1	FDIR	4.5.a Autonomous Vehicle Systems Management
3.3.2	Management & Control	
3.3.3	Distribution & Transmission	3.1.a 300 kWe Fission Power for Electric Propulsion 3.1.c Autonomously Deployable 300 kW In-Space Arrays 3.1.e Multi-MWe Nuclear Power for Electric Propulsion
3.3.4	Wireless Power Transmission	
3.3.5	Conversion & Regulation	3.1.a 300 kWe Fission Power for Electric Propulsion 3.1.c Autonomously Deployable 300 kW In-Space Arrays 3.1.e Multi-MWe Nuclear Power for Electric Propulsion
3.4	*Cross Cutting Technology*	
3.4.0	Cross Cutting Technology	
3.4.1	Analytical Tools	
3.4.2	Green Energy Impact	
3.4.3	Multi-functional Structures	
3.4.4	Alternative Fuels	
4.	**Robotics, Tele-Robotics and Autonomous Systems**	
4.0	*Robotics, Tele-Robotics and Autonomous Systems*	
4.0.0	Robotics, Tele-Robotics and Autonomous Systems	
4.1	*Sensing & Perception*	
4.1.0	Sensing & Perception	
4.1.1	3-D Perception	
4.1.2	Relative Position & Velocity Estimation	
4.1.3	Terrain Mapping, Classification & Characterization	

TABS #	OCT Technology Area	HAT Technology Need
4.1.4	Natural & Man-made Object Recognition	
4.1.5	Sensor Fusion for Sampling & Manipulation	
4.1.6	Onboard Science Data Analysis	4.1.a Precision Landing & Hazard Avoidance
4.2	*Mobility*	
4.2.0	Mobility	
4.2.1	Extreme Terrain Mobility	7.3.c Surface Mobility
4.2.2	Below-Surface Mobility	
4.2.3	Above-Surface Mobility	
4.2.4	Small Body/Microgravity Mobility	4.6.a Automated/Autonomous Rendezvous & Docking, Proximity Operations, and Target Relative Navigation 7.3.a Anchoring Techniques & EVA Tools for u-G Surface Operations 7.3.c Surface Mobility
4.3	*Manipulation*	
4.3.0	Manipulation	
4.3.1	Robot Arms	
4.3.2	Dexterous manipulators	4.3.a Telerobotic control of robotic systems with time delay
4.3.3	Modeling of Contact Dynamics	
4.3.4	Mobile Manipulation	
4.3.5	Collaborative Manipulation	4.4.a Robots Working Side-by-Side with Suited Crew
4.3.6	Robotic Drilling & Sample Processing	
4.4	*Human-Systems Integration*	
4.4.0	Human-Systems Integration	
4.4.1	Multi-Modal Human-Systems Interaction	
4.4.2	Supervisory Control	4.3.a Telerobotic control of robotic systems with time delay 4.4.a Robots Working Side-by-Side with Suited Crew

TABS #	OCT Technology Area	HAT Technology Need
4.4.3	Robot-to-Suit Interfaces	
4.4.4	Intent Recognition & Reaction	4.4.a Robots Working Side-by-Side with Suited Crew
4.4.5	Distributed Collaboration	
4.4.6	Common Human-Systems Interfaces	
4.4.7	Safety, Trust, & Interfacing of Robotic/Human Proximity Operations	4.4.a Robots Working Side-by-Side with Suited Crew
4.5	*Autonomy*	
4.5.0	Autonomy	
4.5.1	Vehicle Systems Management & FDIR	4.3.a Telerobotic control of robotic systems with time delay 4.5.a Autonomous Vehicle Systems Management 7.5.a Mission Control Automation beyond LEO
4.5.2	Dynamic Planning & Sequencing Tools	4.3.a Telerobotic control of robotic systems with time delay
4.5.3	Autonomous Guidance & Control	4.3.a Telerobotic control of robotic systems with time delay 4.6.a Automated/Autonomous Rendezvous & Docking, Proximity Operations, and Target Relative Navigation
4.5.4	Multi-Agent Coordination	4.3.a Telerobotic control of robotic systems with time delay
4.5.5	Adjustable Autonomy	4.3.a Telerobotic control of robotic systems with time delay 4.6.a Automated/Autonomous Rendezvous & Docking, Proximity Operations, and Target Relative Navigation 4.7.a Crew Autonomy beyond LEO
4.5.6	Terrain-Relative Navigation	4.1.a Precision Landing & Hazard Avoidance 4.3.a Telerobotic control of robotic systems with time delay
4.5.7	Path & Motion Planning with Uncertainty	4.3.a Telerobotic control of robotic systems with time delay
4.6	*Autonomous Rendezvous and Docking*	
4.6.0	Autonomous Rendezvous and Docking	
4.6.1	Relative Navigation Sensors (long-, mid-, near-range)	

TABS #	OCT Technology Area	HAT Technology Need
4.6.2	Guidance Algorithms	4.6.a Automated/Autonomous Rendezvous & Docking, Proximity Operations, and Target Relative Navigation
4.6.3	Docking & Capture Mechanisms/Interfaces	4.6.a Automated/Autonomous Rendezvous & Docking, Proximity Operations, and Target Relative Navigation
4.6.4	Mission/System Management for Autonomy/Automation	
4.7	*RTA Systems Engineering*	
4.7.0	RTA Systems Engineering	
4.7.1	Modularity/Commonality	
4.7.2	Verification & Validation of Complex Adaptive Systems	4.7.c Common Avionics 11.2.a Advanced Software Development/Tools
4.7.3	Onboard Computing	
5.	**Communications and Navigation**	
5.0	*Communications and Navigation*	
5.0.0	Communications and Navigation	
5.1	*Optical Comm. And Navigation*	
5.1.0	Optical Comm. And Navigation	
5.1.1	Detector Development	
5.1.2	Large Apertures	
5.1.3	Lasers	
5.1.4	Acquisition and Tracking	
5.1.5	Atmospheric Mitigation	
5.2	*Radio Frequency Communications*	
5.2.0	Radio Frequency Communications	
5.2.1	Spectrum Efficient Technologies	

TABS #	OCT Technology Area	HAT Technology Need
5.2.2	Power Efficient Technologies	
5.2.3	Propagation	
5.2.4	Flight and Ground Systems	
5.2.5	Earth Launch and Reentry Comm	
5.2.6	Antennas	
5.3	*Internetworking*	
5.3.0	Internetworking	
5.3.1	Disruptive Tolerant Networking	
5.3.2	Adaptive Network Topology	
5.3.3	Information Assurance	
5.3.4	Integrated Network Management	
5.4	*Position, Navigation, and Timing*	
5.4.0	Position, Navigation, and Timing	
5.4.1	Timekeeping and Time Distribution (combining 5.4.1 and 5.4.2)	5.2.a High Data Rate Forward Link (Flight) Communications 5.4.b In-Space Timing and Navigation for Autonomy
5.4.3	Onboard Auto Navigation and Maneuvering	5.4.b In-Space Timing and Navigation for Autonomy
5.4.4	Sensors and Vision Processing Systems	
5.4.5	Relative and Proximity Navigation	5.2.a High Data Rate Forward Link (Flight) Communications 5.4.a High Rate, Adaptive, Internetworked Proximity Communications
5.4.6	Auto Precision Formation Flying	
5.4.7	Auto Approach and Landing	
5.5	*Integrated Technologies*	
5.5.0	Integrated Technologies	
5.5.1	Radio Systems	5.2.a High Data Rate Forward Link (Flight) Communications

TABS #	OCT Technology Area	HAT Technology Need
5.5.1	Radio Systems	5.4.a High Rate, Adaptive, Internetworked Proximity Communications 5.5.a Quad Function Hybrid RF/Optical Comm, Optical Ranging, RF Imaging System
5.5.2	Ultra Wideband	
5.5.3	Cognitive Networks	
5.5.4	Science from the Comm System	
5.5.5	Hybrid Opt Comm & Navigation Sensors	5.5.a Quad Function Hybrid RF/Optical Comm, Optical Ranging, RF Imaging System
5.5.6	RF/Optical Hybrid Technology	5.5.a Quad Function Hybrid RF/Optical Comm, Optical Ranging, RF Imaging System
5.6	*Revolutionary Concepts*	
5.6.0	Revolutionary Concepts	
5.6.1	X-Ray Navigation	
5.6.2	X-Ray Communications	
5.6.3	Neutrino-Based Navigation and Tracking	
5.6.4	Quantum Key Distribution	
5.6.5	Quantum Communications	
5.6.6	SQIF Microwave Amplifier	
5.6.7	Reconfigurable Large Apertures Using Nanosat Constellations (renamed)	
6.	**Human Health, Life Support & Habitation Systems**	
6.0	*Human Health, Life Support & Habitation Systems*	
6.0.0	Human Health, Life Support & Habitation Systems	
6.1	*Environmental Control Life Support & Habitation Systems*	
6.1.0	Environmental Control Life Support & Habitation Systems	
6.1.1	Air Revitalization	6.1.a Closed-Loop, High Reliability, Life Support Systems 6.1.b High Reliability Life Support Systems
6.1.2	Water Recovery and Management	6.1.a Closed-Loop, High Reliability, Life Support Systems

TABS #	OCT Technology Area	HAT Technology Need
6.1.2	Water Recovery and Management	6.1.b High Reliability Life Support Systems
6.1.3	Waste Management	6.1.a Closed-Loop, High Reliability, Life Support Systems 6.1.b High Reliability Life Support Systems
6.1.4	Habitation	6.1.a Closed-Loop, High Reliability, Life Support Systems 6.1.b High Reliability Life Support Systems 6.3.e Deep Space Mission Human Factors and Habitability
6.2	*Extravehicular Activity Systems*	
6.2.0	Extravehicular Activity Systems	
6.2.1	Pressure Garment	6.2.a Deep Space Suit (Block 1) 6.2.b Lunar Surface Space Suit (Block 2) 6.2.c Mars Surface Space Suit (Block 3)
6.2.2	Portable Life Support System	6.2.a Deep Space Suit (Block 1)
6.2.3	Power, Avionics and Software	6.2.a Deep Space Suit (Block 1)
6.3	*Human Health and Performance*	
6.3.0	Human Health and Performance	
6.3.1	Medical Diagnosis/Prognosis	6.3.a Long Duration Spaceflight Medical Care
6.3.2	Long Duration Health	6.3.a Long Duration Spaceflight Medical Care 6.3.c Microgravity Biomedical Counter-Measures for Long Duration Spaceflight 6.3.d Microgravity Biomedical Counter-Measures - Optimized Exercise Equipment
6.3.3	Behavioral Health	6.3.b Long-Duration Spaceflight Behavioral Health and Performance
6.3.4	Human Factors	6.3.e Deep Space Mission Human Factors and Habitability
6.4	*Environmental Monitoring and Safety*	
6.4.0	Environmental Monitoring and Safety	
6.4.1	Sensors: Air, Water, Microbial, etc	6.4.a In-Flight Environmental Monitoring
6.4.2	Fire: Detection, Suppression, Recovery	6.4.b Fire Prevention, Detection & Suppression (reduced pressure)

TABS #	OCT Technology Area	HAT Technology Need
6.4.3	Protective Clothing/Breathing	
6.4.4	Remediation	
6.5	*Radiation*	
6.5.0	Radiation	
6.5.1	Risk assessment modeling	6.5.a Space Radiation Protection – Galactic Cosmic Rays (GCR) 6.5.b Space Radiation Protection – Solar Particle Events (SPE)
6.5.2	Radiation mitigation	6.5.a Space Radiation Protection – Galactic Cosmic Rays (GCR) 6.5.b Space Radiation Protection – Solar Particle Events (SPE)
6.5.3	Protection systems	6.5.a Space Radiation Protection – Galactic Cosmic Rays (GCR) 6.5.b Space Radiation Protection – Solar Particle Events (SPE) 6.5.c Space Radiation Shielding – SPE
6.5.4	Radiation prediction	
6.5.5	Monitoring technology	6.5.b Space Radiation Protection – Solar Particle Events (SPE)
7.	**Human Exploration Destination Systems**	
7.0	*Human Exploration Destination Systems*	
7.0.0	Human Exploration Destination Systems	
7.1	*In-Situ Resource Utilization*	
7.1.0	In-Situ Resource Utilization	
7.1.1	Destination Reconnaissance, Prospecting, & Mapping	
7.1.2	Resource Acquisition	7.1.a In-Situ Resource Utilization (ISRU) - Lunar: Oxygen/Water Extraction from Lunar Regolith 7.1.b In-Situ Resource Utilization (ISRU) - Mars: Oxygen from Atmosphere & Water Extraction from Soil
7.1.3	Consumables Production	7.1.a In-Situ Resource Utilization (ISRU) - Lunar: Oxygen/Water Extraction from Lunar Regolith 7.1.b In-Situ Resource Utilization (ISRU) - Mars: Oxygen from Atmosphere & Water Extraction from Soil

TABS #	OCT Technology Area	HAT Technology Need
7.1.4	Manufacturing Products & Infrastructure Emplacement	
7.2	*Sustainability & Supportability*	
7.2.0	Sustainability & Supportability	
7.2.1	Autonomous Logistics Management	4.7.a Crew Autonomy beyond LEO
7.2.2	Maintenance Systems	4.5.a Autonomous Vehicle Systems Management
7.2.3	Repair Systems	
7.2.4	Food Production, Processing, and Preservation	
7.3	*Advanced Human Mobility Systems*	
7.3.0	Advanced Human Mobility Systems	
7.3.1	EVA Mobility	7.3.b Suit Port
7.3.2	Surface Mobility	7.3.a Anchoring Techniques & EVA Tools for u-G Surface Operations 7.3.c Surface Mobility 14.2.a Thermal Control
7.3.3	Off-Surface Mobility	
7.4	*Advanced Habitat Systems*	
7.4.0	Advanced Habitat Systems	
7.4.1	Integrated Habitat Systems	
7.4.2	Habitat Evolution	12.1.a Inflatable: Structures & Materials for Inflatable Modules
7.4.3	Smart Habitats	4.7.a Crew Autonomy beyond LEO
7.4.4	Artificial Gravity	
7.5	*Mission Operations & Safety*	
7.5.0	Mission Operations & Safety	
7.5.1	Crew Training	
7.5.4	Planetary Safety	

TABS #	OCT Technology Area	HAT Technology Need
7.5.5	Integrated Flight Operations Systems	
7.5.6	Integrated Risk Assessment Tools	
7.6	*Cross-Cutting Systems*	
7.6.0	Cross-Cutting Systems	
7.6.2	Construction & Assembly	
7.6.3	Particulate Contamination Prevention & Mitigation	7.6.a Dust Mitigation
8.	**Science Instruments, Observatories & Sensor Systems**	
8.0	*Science Instruments, Observatories & Sensor Systems*	
8.0.0	Science Instruments, Observatories & Sensor Systems	
8.1	*Science Instruments*	
8.1.0	Science Instruments	
8.1.1	Detectors and Focal Planes	
8.1.2	Electronics	
8.1.3	Optical Components	
8.1.4	Microwave/Radio	
8.1.5	Lasers	
8.1.6	Cryogenic/Thermal	
8.2	*Observations*	
8.2.0	Observations	
8.2.1	Mirror Systems	
8.2.2	Structures and Antenna	
8.2.3	Distributed Aperture	
8.3	*Sensor Systems*	
8.3.0	Sensor Systems	

TABS #	OCT Technology Area	HAT Technology Need
8.3.1	Particles: charged and neutral	
8.3.2	Fields and Waves	
8.3.3	In-Situ	
9.	**Entry, Descent and Landing Systems**	
9.0	*Entry, Descent and Landing Systems*	
9.0.0	Entry, Descent and Landing Systems	
9.1	*Aeroassist & Entry*	
9.1.0	Aeroassist & Entry	
9.1.1	Rigid Thermal Protection Systems	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions 9.1.b Entry, Descent, and Landing (EDL) Technologies - Earth Return
9.1.2	Flexible Thermal Protection Systems	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions 9.1.b Entry, Descent, and Landing (EDL) Technologies - Earth Return
9.1.3	Rigid Hypersonic Decelerators	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions 9.1.b Entry, Descent, and Landing (EDL) Technologies - Earth Return
9.1.4	Deployable Hypersonic Decelerators	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions 9.1.b Entry, Descent, and Landing (EDL) Technologies - Earth Return
9.2	*Descent*	
9.2.0	Descent	
9.2.1	Attached Deployable Decelerators	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.2.2	Trailing Deployable Decelerators	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.2.3	Supersonic Retropropulsion	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.3	*Landing*	
9.3.0	Landing	
9.3.1	Touchdown Systems	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.3.2	Egress and Deployment Systems	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions

TABS #	OCT Technology Area	HAT Technology Need
9.3.3	Propulsion Systems	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.3.5	Small Body Systems	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.4	*Vehicle Systems Technology*	
9.4.0	Vehicle Systems Technology	
9.4.2	Separation Systems	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.4.3	System Integration and Analyses	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions 9.1.b Entry, Descent, and Landing (EDL) Technologies - Earth Return
9.4.4	Atmosphere & surface characterization	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.4.5	Modeling and Simulation	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions 9.1.b Entry, Descent, and Landing (EDL) Technologies - Earth Return
9.4.6	Instrumentation and Health Monitoring	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
9.4.7	GN&C Sensors and Systems	9.1.a Entry, Descent, and Landing (EDL) Technologies - Mars Exploration Class Missions
10.	**Nanotechnology**	
10.0	*Nanotechnology*	
10.0.0	Nanotechnology	
10.1	*Engineered Materials and Structures*	
10.1.0	Engineered Materials and Structures	
10.1.1	Lightweight Materials	
10.1.2	Damage Tolerant Systems	
10.1.3	Coatings	
10.1.4	Adhesives	
10.1.5	Thermal Protection and Control	
10.2	*Energy Generation and Storage*	
10.2.0	Energy Generation and Storage	
10.2.1	Energy Storage	

TABS #	OCT Technology Area	HAT Technology Need
10.2.2	Energy Generation	
10.3	*Propulsion*	
10.3.0	Propulsion	
10.3.1	Propellants	
10.3.2	Propulsion Components	
10.3.3	In-Space propulsion	
10.4	*Electronics, Sensors and Devices*	
10.4.0	Electronics, Sensors and Devices	
10.4.1	Sensors and Actuators	
10.4.2	Nanoelectronics	
10.4.3	Miniature Instruments	
11.	**Modeling, Simulation, Information Technology and Processing**	
11.0	*Modeling, Simulation, Information Technology and Processing*	
11.0.0	Modeling, Simulation, Information Technology and Processing	
11.1	*Computing*	
11.1.0	Computing	
11.1.1	Flight Computing	4.7.c Common Avionics 11.2.a Advanced Software Development/Tools
11.1.2	Ground Computing	11.2.a Advanced Software Development/Tools
11.2	*Modeling*	
11.2.0	Modeling	
11.2.1	Software Modeling and Model-Checking	11.2.a Advanced Software Development/Tools
11.2.2	Integrated Hardware and Software Modeling	
11.2.3	Human-System Performance Modeling	

TABS #	OCT Technology Area	HAT Technology Need
11.2.4	Science Modeling	
11.2.5	Frameworks, Languages, Tools, and Standards	11.2.a Advanced Software Development/Tools
11.3	*Simulation*	
11.3.0	Simulation	
11.3.1	Distributed Simulation	
11.3.2	Integrated System Lifecycle Simulation	
11.3.3	Simulation-Based Systems Engineering	
11.3.4	Simulation-Based Training and Decision Support Systems	
11.4	*Information Processing*	
11.4.0	Information Processing	
11.4.1	Science, Engineering, and Mission Data Lifecycle	
11.4.2	Intelligent data understanding	
11.4.3	Semantic Technologies	
11.4.4	Collaborative Science and Engineering	
11.4.5	Advanced mission systems	
12.	**Materials, Structures, Mechanical Systems and Manufacturing**	
12.0	*Materials, Structures, Mechanical Systems and Manufacturing*	
12.0.0	Materials, Structures, Mechanical Systems and Manufacturing	
12.1	*Materials*	
12.1.0	Materials	
12.1.1	Lightweight Structure	12.1.b Lightweight and Efficient Structures and Materials
12.1.2	Computational Design	
12.1.3	Flexible Material Systems	

TABS #	OCT Technology Area	HAT Technology Need
12.1.4	Environment	
12.1.5	Special Materials	
12.2	*Structures*	
12.2.0	Structures	
12.2.1	Lightweight Concepts	12.1.a Inflatable: Structures & Materials for Inflatable Modules 12.1.b Lightweight and Efficient Structures and Materials
12.2.2	Design and Certification Methods	12.1.b Lightweight and Efficient Structures and Materials
12.2.3	Reliability and Sustainment	
12.2.4	Test Tools and Methods	
12.2.5	Innovative, Multifunctional Concepts	12.1.a Inflatable: Structures & Materials for Inflatable Modules 12.1.b Lightweight and Efficient Structures and Materials
12.3	*Mechanical Systems*	
12.3.0	Mechanical Systems	12.3.b Low Temperature Mechanisms
12.3.1	Deployables, Docking and Interfaces	
12.3.2	Mechanism Life Extension Systems	12.3.a Mechanisms for Long Duration, Deep Space Missions
12.3.3	Electro-mechanical, Mechanical and Micromechanisms	
12.3.4	Design and Analysis Tools and Methods	
12.3.5	Reliability / Life Assessment / Health Monitoring	
12.3.6	Certification Methods	
12.4	*Manufacturing*	
12.4.0	Manufacturing	
12.4.1	Manufacturing Processes	12.1.b Lightweight and Efficient Structures and Materials
12.4.2	Intelligent Integrated Manufacturing and Cyber Physical Systems	
12.4.3	Electronics and Optics Manufacturing Process	

TABS #	OCT Technology Area	HAT Technology Need
12.4.4	Sustainable Manufacturing	
12.5	*Cross-Cutting*	
12.5.0	Cross-Cutting	
12.5.1	Nondestructive Evaluation	
12.5.2	Model-Based Certification and Sustainment Methods	
12.5.3	Loads and Environments	
13.	**Ground and Launch Systems Processing**	
13.0	*Ground and Launch Systems Processing*	
13.0.0	Ground and Launch Systems Processing	
13.1	*Technologies to Optimize the Operational Life-Cycle*	
13.1.0	Technologies to Optimize the Operational Life-Cycle	
13.1.1	Storage, Distribution and Conservation of Fluids	13.1.a Ground Systems: Low Loss Cryogenic Ground Systems Storage and Transfer
13.1.2	Automated Alignment, Coupling, and Assembly Systems	
13.1.3	Autonomous Command and Control for Ground and Integrated Vehicle/Ground Systems	
13.2	*Environmental and Green Technologies*	
13.2.0	Environmental and Green Technologies	
13.2.1	Corrosion Prevention, Detection, and Mitigation	13.2.a Ground Systems: Corrosion Detection & Control
13.2.2	Environmental Remediation and Site Restoration	
13.2.3	Preservation of Natural Ecosystems	13.3.a Ground Systems: Fault Detection, Isolation, and Recovery
13.2.4	Alternate Energy Prototypes	
13.3	*Technologies to Increase Reliability and Mission Availability*	
13.3.0	Technologies to Increase Reliability and Mission Availability	4.5.a Autonomous Vehicle Systems Management 13.3.b Ground Systems: Wiring Fault Detection and Repair

TABS #	OCT Technology Area	HAT Technology Need
13.3.1	Advanced Launch Technologies	
13.3.2	Environment-Hardened Materials and Structures	
13.3.3	Inspection, Anomaly Detection and Identification	
13.3.4	Fault Isolation and Diagnostics	13.3.a Ground Systems: Fault Detection, Isolation, and Recovery
13.3.5	Prognostics Technologies	13.3.a Ground Systems: Fault Detection, Isolation, and Recovery
13.3.6	Repair, Mitigation, and Recovery Technologies	
13.3.7	Communications, Networking, Timing and Telemetry	
13.4	*Technologies to Improve Mission Safety/Mission Risk*	
13.4.0	Technologies to Improve Mission Safety/Mission Risk	
13.4.1	Range tracking, surveillance & flight safety technologies	
13.4.2	Landing and Recovery Systems and Components	
13.4.3	Weather Prediction and Mitigation	
13.4.4	Robotics/Telerobotics	
13.4.5	Safety Systems	
14.	**Thermal Management Systems**	
14.0	*Thermal Management Systems*	
14.0.0	Thermal Management Systems	
14.1	*Cryogenic Systems*	
14.1.0	Cryogenic Systems	
14.1.1	Passive Thermal Control	14.1.a In-Space Cryogenic Propellant Storage (Zero Boil Off LO2; Reduced/Zero Boil Off LH2)
14.1.2	Active Thermal Control	14.1.a In-Space Cryogenic Propellant Storage (Zero Boil Off LO2; Reduced/Zero Boil Off LH2)
14.1.3	Integration and Modeling	
14.2	*Thermal Control Systems*	
14.2.0	Thermal Control Systems	

TABS #	OCT Technology Area	HAT Technology Need
14.2.1	Heat Acquisition	
14.2.2	Heat Transfer	
14.2.3	Heat Rejection & Energy Storage	14.2.a Thermal Control
14.3	*Thermal Protection Systems*	
14.3.0	Thermal Protection Systems	
14.3.1	Entry/Ascent TPS	14.3.a Robust Ablative Heat Shield (Beyond Lunar Return) - Thermal Protection System 14.3.b Robust Ablative Heat Shield (Lunar Return) - Thermal Protection Systems
14.3.2	Plume Shielding (convective & radiative)	
14.3.3	Sensor systems & measurement technologies	